

Biogeochemistry

- 1) Reservoirs – storage
- 2) Fluxes - transfer
- 3) Timescales

Turnover time (T)

The ratio of the 'mass' of a reservoir to its rate of removal (S): $T = M/S$

If we look at a case of UMBC which has
8,475 undergraduate students
1,457 graduate students

The total turnover time for UMBC students if 2275 will graduate this year is:

$$T = 9932 \text{ (students)} / 2275 \text{ (students per year)} = 4.36 \text{ years}$$

In some systems there is more than one mechanism at work, each with its own specific turnover time. In the case of UMBC we have undergraduates (T_u) and graduates (T_g).

$$T_u = 8475 / 1695 = 5 \text{ years}$$

$$T_g = 1457 / 580 = 2.51 \text{ years}$$

Adjustment or response time (T_a)

The timescale characterizing the decay of an instantaneous pulse input into the reservoir. Adjustment time is also used to characterize the adjustment of the mass of the reservoir following a change in source strength.

Lifetime

A general term often without a specific definition. In general it often is meant to be synonymous with adjustment time. However in terms of atmospheric chemistry it is often synonymous with turnover time.

The Global Carbon Cycle

How do we study the carbon cycle?

- 1) Information exchange between researchers
- 2) Extant data analysis (studying existing datasets)
- 3) Monitoring
- 4) Experimentation
- 5) Modeling

Carbon Units

GTC – Gigatonnes of carbon

1st of all it is not tonnes not tons (e.g. it is a metric unit)

giga represents 10^9

a tonne is 10^3 kg is equal to 10^6 g, therefore $1 \text{ GTC} = 10^{15} \text{ g carbon}$

Natural variability versus human impacts

Often there is a tendency to wish to skip right to studying human impacts, however to study human impacts on the carbon cycle it is first necessary to study how it behaves in the absence of human activity.

The Carbon Cycle on Geologic Timescales

We know that the Earth's climate has change through time and that CO₂ has changed through time as well. Earth is not Venus, which has an atmosphere rich in CO₂, nor has our atmosphere in recent times always had enough CO₂ to sustain photosynthesis, thus it seems a series of feedback mechanisms must operate to maintain CO₂ in the atmosphere within certain bounds.

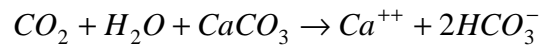
On the longest timescales on earth, the carbon cycle essentially represents a balance between the amount of rocks that are weathered which sequesters CO₂ from the atmosphere and by degassing and igneous activities that return CO₂ to the atmosphere.

Most of the carbon on earth is stored in rocks, though this reservoir plays a very small role in fluxes of carbon on earth on human timescales. In rocks most of the carbon is stored in the following forms

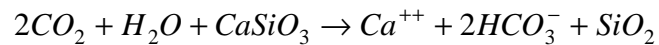
- 1) Kerogen (organic matter)
- 2) CaCO_3 (limestone)
- 3) $\text{CaMg}(\text{CO}_3)_2$ (dolomite)
- 4) Silicates

When rock weathers the following reactions occur which remove carbon dioxide from the atmosphere

Carbonate Rock weathering



Silicate Rock weathering



These weathered rocks are returned to the oceans by the rivers where 80% of the carbon ends up as carbonate (CaCO_3) and 20% as dead organic matter. In the oceans carbonate formations occurs as follows:



As it is possible to see that the carbon dioxide released in the formation of carbonate rocks in the oceans could balance out the carbon dioxide sequestered when carbonate rocks weather. However, this leaves silicate rock weathering unbalanced and without a mitigating mechanism silicate rock weathering would remove all carbon dioxide from the atmosphere. Obviously this has not happened so what is the mitigating factor? This mitigating factor is the metamorphic/magmatic breakdown of carbonate.

